

WHAT IS CLAIMED IS:

1. An optical transmission system for optically transmitting an angle-modulated signal, comprising:

an optical modulating portion for converting said angle-modulated signal into an optical-modulated signal;

an interference portion for separating said optical-modulated signal into a plurality of optical signals having predetermined difference in propagation delay and then combining the optical signals; and

an optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from said interference portion into an electrical signal,

said interference portion and said optical/electrical converting portion constituting a delayed detection system of an optical signal, and the delayed detection system performing conversion processing of an optical signal into an electrical signal and angle demodulation processing simultaneously.

2. The optical transmission system according to claim 1, wherein said angle-modulated signal is an FM signal obtained by subjecting an analog signal to frequency modulation.

3. The optical transmission system according to claim 1,

wherein said angle-modulated signal is a PM signal obtained by subjecting an analog signal to phase modulation.

4. The optical transmission system according to claim 1, wherein said angle-modulated signal is an FSK modulated signal obtained by subjecting a digital signal to frequency modulation.

5. The optical transmission system according to claim 1, wherein said angle-modulated signal is a PSK modulated signal obtained by subjecting a digital signal to phase modulation.

6. The optical transmission system according to claim 1, wherein said optical modulating portion generates an optical-intensity-modulated signal as said optical-modulated signal.

7. The optical transmission system according to claim 6, wherein

said optical modulating portion comprises:

a light source for outputting a light with a given optical intensity and a given wavelength;

an optical branch portion for branching the light from said light source into two;

first and second optical phase modulating portions, provided for the two outputted lights from said optical branch

portion respectively, for subjecting the outputted lights to optical phase modulation using said angle-modulated signal as an original signal; and

an optical coupling portion for combining the two optical-phase-modulated signals outputted from said first and second optical phase modulating portions.

8. The optical transmission system according to claim 6, wherein

said interference portion comprises:

an optical branch portion for branching an inputted optical signal into a first optical signal and a second optical signal;

an optical delay portion for providing the second optical signal outputted from said optical branch portion with a predetermined delay; and

an optical combining portion for combining the first optical signal outputted from said optical branch portion and the second optical signal outputted from said optical delay portion.

9. The optical transmission system according to claim 6, wherein

said optical modulating portion comprises:

a light source for outputting a light with a given optical intensity and a given wavelength;

an optical branch portion for branching the light from said light source into two;

first and second optical phase modulating portions, provided for the two outputted lights from said optical branch portion respectively, for each subjecting each of the outputted lights to optical phase modulation using said angle-modulated signal as an original signal; and

an optical directional coupling portion for combining the two optical-phase-modulated signals outputted from said first and second optical phase modulating portions and then dividing the resultant signal into first and second optical signals in which optical-intensity modulated components are set in opposite phases to each other, and

said interference portion comprises:

an optical delay portion for providing the second optical signal outputted from said optical directional coupling portion with a predetermined delay; and

an optical combining portion for combining the first optical signal outputted from said optical directional coupling portion and the second optical signal outputted from said optical delay portion.

10. The optical transmission system according to claim 6, wherein

said interference portion comprises:

an optical waveguide portion for guiding the optical signal outputted from said optical modulating portion; and

first and second optical transparent/reflecting portions, cascaded on said optical waveguide portion at a prescribed interval, for respectively transmitting parts of the inputted optical signals and reflecting the remained parts, and

propagation time in which an optical signal goes and returns between said first and second optical transparent/reflecting portions is said predetermined difference in propagation delay.

11. The optical transmission system according to claim 1, wherein said optical modulating portion generates an optical-amplitude-modulated signal as said optical-modulated signal.

12. The optical transmission system according to claim 11, wherein

said optical modulating portion comprises:

a light source for outputting a light with a given optical intensity and a given wavelength;

an optical branch portion for branching the light from said light source into two;

first and second optical phase modulating portions, provided for the two outputted lights from said optical branch portion respectively, for each subjecting each of the outputted

lights to optical phase modulation using said angle-modulated signals as an original signal; and

an optical coupling portion for combining the two optical-phase-modulated signals outputted from said first and second optical phase modulating portions.

13. The optical transmission system according to claim 11, wherein

said interference portion comprises:

an optical branch portion for branching the inputted optical signal into a first optical signal and a second optical signal;

an optical delay portion for providing the second optical signal outputted from said optical branch portion with a predetermined delay; and

an optical combining portion for combining the first optical signal outputted from said ~~second~~ optical branch portion and the second optical signal outputted from said optical delay portion.

14. The optical transmission system according to claim 11, wherein

said optical modulating portion comprises:

a light source for outputting a light with a given optical intensity and a given wavelength;

an optical branch portion for branching the light from said light source into two;

first and second optical phase modulating portions, provided for the two outputted lights from said optical branch portion respectively, for each subjecting each of the outputted lights to optical phase modulation using said angle-modulated signal as an original signal; and

an optical directional coupling portion for combining the two optical-phase-modulated signals outputted from said first and second optical phase modulating portions and then dividing the resultant signal into first and second optical signals in which optical-amplitude-modulated components are set in opposite phases to each other, and

said interference portion comprises:

an optical delay portion for providing the second optical signal outputted from said optical directional coupling portion with a predetermined delay; and

an optical combining portion for combining the first optical signal outputted from said optical directional coupling portion and the second optical signal outputted from said optical delay portion.

15. The optical transmission system according to claim 11, wherein

said interference portion comprises:

an optical waveguide portion for guiding the optical signal outputted from said optical modulating portion; and

first and second optical transparent/reflecting portions, cascaded on said optical waveguide portion at a predetermined interval, for respectively transmitting parts of the inputted optical signals and reflecting the remained parts, and

propagation time in which an optical signal goes and returns between said first and second optical transparent/reflecting portions is said predetermined difference in propagation delay.

16. The optical transmission system according to claim 12, wherein predetermined optical phase modulation is performed in said first and second optical phase modulating portions so that difference between the optical phase shift by said first optical phase modulating portion and the optical phase shift by said second optical phase modulating portion is set in phase with said angle-modulated signal.

17. The optical transmission system according to claim 14, wherein predetermined optical phase modulation is performed in said first and second optical phase modulating portions so that difference between the optical phase shift by said first optical phase modulating portion and the optical phase shift by said second optical phase modulating portion is set in phase



with said angle-modulated signal.

18. The optical transmission system according to claim 12, wherein predetermined optical phase modulation is performed in said first and second optical phase modulating portions so that difference between the optical phase shift by said first optical phase modulating portion and the optical phase shift by said second optical phase modulating portion is set in opposite phases with said angle-modulated signal.

19. The optical transmission system according to claim 14, wherein predetermined optical phase modulation is performed in said first and second optical phase modulating portions so that difference between the optical phase shift by said first optical phase modulating portion and the optical phase shift by said second optical phase modulating portion is set in opposite phases with said angle-modulated signal.

20. The optical transmission system according to claim 1, wherein a product value of a center angular frequency of said angle-modulated signal and the predetermined difference in propagation delay in said interference portion is set to be equal to  $\pi/2$ .

21. The optical transmission system according to claim 4,

wherein the predetermined difference in propagation delay in said interference portion is set to be equal to one symbol length of said digital signal.

22. The optical transmission system according to claim 5, wherein the predetermined difference in propagation delay in said interference portion is set to be equal to one symbol length of said digital signal.

23. The optical transmission system according to claim 8, wherein polarization states of the first optical signal and the second optical signal to be combined in said optical combining portion are set to be the same with each other.

24. The optical transmission system according to claim 9, wherein polarization states of the first optical signal and the second optical signal to be combined in said optical combining portion are set to be the same with each other.

25. The optical transmission system according to claim 13, wherein polarization states of the first optical signal and the second optical signal to be combined in said optical combining portion are set to be the same with each other.

26. The optical transmission system according to claim 14,

wherein polarization states of the first optical signal and the second optical signal to be combined in said optical combining portion are set to be the same with each other.

27. The optical transmission system according to claim 10, wherein polarization states of the optical signal transmitting through said first and second optical transparent/reflecting portions along said optical waveguide portion and the optical signal transmitting through said first optical transparent/reflecting portion, reflected at said second optical transparent/reflecting portion, reflected at said first optical transparent/reflecting portion and transmitting through said second optical transparent/reflecting portion are set to be the same with each other.

28. The optical transmission system according to claim 15, wherein polarization states of the optical signal transmitting through said first and second optical transparent/reflecting portions along said optical waveguide portion and the optical signal transmitting through said first optical transparent/reflecting portion, reflected at said second optical transparent/reflecting portion, reflected at said first optical transparent/reflecting portion and transmitting through said second optical transparent/reflecting portion are set to be the same with each other.

29. The optical transmission system according to claim 8, wherein

said optical modulating portion and said interference portion are connected with a first optical waveguide portion,

said interference portion and said optical/electrical converting portion are connected with a second optical waveguide portion, and

said first and/or second optical waveguide portions are composed of single-mode optical fibers.

30. The optical transmission system according to claim 13, wherein

said optical modulating portion and said interference portion are connected with a first optical waveguide portion,

said interference portion and said optical/electrical converting portion are connected with a second optical waveguide portion, and

said first and/or second optical waveguide portions are composed of single-mode optical fibers.

31. The optical transmission system according to claim 9, wherein

said interference portion and said optical/electrical converting portion are connected with an optical waveguide portion, and

said optical waveguide portion is composed of a single-mode optical fiber.

32. The optical transmission system according to claim 14, wherein

said interference portion and said optical/electrical converting portion are connected with an optical waveguide portion, and

said optical waveguide portion is composed of a single-mode optical fiber.

33. The optical transmission system according to claim 10, wherein a whole or a part of the optical waveguide portion in said interference portion is composed of a single-mode optical fiber.

34. The optical transmission system according to claim 15, wherein a whole or a part of the optical waveguide portion in said interference portion is composed of a single-mode optical fiber.

35. The optical transmission system according to claim 1, further comprising an amplitude adjusting portion for adjusting an amplitude of said angle-modulated signal and outputting said angle-modulated signal of a constant amplitude.

36. The optical transmission system according to claim 1, further comprising a bandwidth limiting portion for limiting a band of said angle-modulated signal.

37. An optical transmitter for optically transmitting an angle-modulated signal, comprising:

an optical modulating portion for converting said angle-modulated signal into an optical-modulated signal; and

an interference portion for separating said optical-modulated signal into a plurality of optical signals having predetermined difference in propagation delay and then combining the optical signals, and

said optical transmitter transmitting the combined optical signal outputted from said interference portion.

38. The optical transmitter according to claim 37, wherein said angle-modulated signal is an FM signal obtained by subjecting an analog signal to frequency modulation.

39. The optical transmitter according to claim 37, wherein said angle-modulated signal is a PM signal obtained by subjecting an analog signal to phase modulation.

40. The optical transmitter according to claim 37, wherein said angle-modulated signal is an FSK modulated signal obtained

by subjecting a digital signal to frequency modulation.

41. The optical transmitter according to claim 37, wherein said angle-modulated signal is a PSK modulated signal obtained by subjecting a digital signal to phase modulation.

42. The optical transmitter according to claim 37, wherein said optical modulating portion generates an optical-intensity-modulated signal as said optical-modulated signal.

43. The optical transmitter according to claim 37, wherein said optical modulating portion generates an optical-amplitude-modulated signal as said optical-modulated signal.

44. An optical receiver for receiving an optical-modulated signal and acquiring a demodulated signal of the optical-modulated signal, comprising:

an interference portion for separating said received optical-modulated signal into a plurality of optical signals having predetermined difference in propagation delay and then combining the optical signals; and

an optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from said interference portion into an electrical signal, and

said interference portion and said optical/electrical converting portion constituting a delayed detection system of an optical signal and the delayed detection system performing conversion processing of an optical signal into an electrical signal and angle demodulation processing simultaneously.

45. The optical receiver according to claim 44, wherein said optical-modulated signal is generated from a  $2^n$ -phase ( $n$  is an integer of not less than two) PSK electrical-modulated signal as an original signal,

said interference portion includes:

a received light dividing portion for dividing an inputted optical signal into  $2^{n-1}$  received lights; and

first to  $2^{n-1}$ th optical interference circuits, provided corresponding to said  $2^{n-1}$  received lights respectively, for each branching each of the received lights into a first optical signal and a second optical signal, providing the second optical signal with a predetermined delay and then combining the first and second optical signals, and

said optical/electrical signals are provided corresponding to said first to  $2^{n-1}$ th optical interference circuits respectively.

46. The optical receiver according to claim 45, wherein said optical-modulated signal is generated from a



quadrature PSK electrical-modulated signal as an original signal,

said interference portion includes:

a received light dividing portion for dividing an inputted optical signal into a first received light and a second received light;

a first optical interference circuit for branching said first received light into a first optical signal and a second optical signal, providing the second optical signal with a first predetermined delay and then combining the first and second optical signals; and

a second optical interference circuit for branching said second received light into a first optical signal and a second optical signal, providing the second optical signal with a second predetermined delay and then combining the first and second optical signals, and

the first predetermined delay in said first optical interference circuit and the second predetermined delay in said second optical interference circuit are both set to have the absolute magnitude of  $\frac{1}{2}$  symbol length of said digital signal and be in opposite phases to each other.

47. An optical transmission system for optically transmitting an angle-modulated signal, comprising:

an optical modulating portion for converting said angle-

modulated signal into an optical-modulated signal;

an optical branch portion for branching the optical-modulated signal outputted from said optical modulating portion into two signals at least, a first optical-modulated signal and a second optical-modulated signal;

an interference portion for separating the first optical-modulated signal outputted from said optical branch portion into a plurality of optical signals having predetermined difference in propagation delay and then combining the optical signals;

a first optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from said interference portion into an electrical signal; and

a second optical/electrical converting portion, having square-law-detection characteristics, for converting the second optical-modulated signal outputted from said optical branch portion into an electrical signal.

48. The optical transmission system according to claim 47, further comprising:

a local light source for outputting a light of a predetermined wavelength; and

an optical combining portion, inserted between said optical branch portion and said second optical/electrical converting

portion, for combining the second optical-modulated signal outputted from said optical branch portion and the light from said local light source,

wherein said second optical/electrical converting portion heterodyne detects the combined optical signal outputted from said optical combining portion and then converts the optical signal into an electrical signal.

49. The optical transmission system according to claim 47, further comprising:

a local light source for outputting a light of a predetermined wavelength; and

an optical combining portion, inserted between said optical modulating portion and said optical branch portion, for combining the optical-modulated signal outputted from said optical modulating portion and the light from said local light source,

wherein said second optical/electrical converting portion heterodyne detects the second optical-modulated signal outputted from said optical branch portion and converts the optical-modulated signal into an electrical signal.

50. An optical transmission system for optically transmitting an angle-modulated signal, comprising:

an optical modulating portion for converting said angle-

modulated signal into an optical-modulated signal;

a local light source for outputting a light of a predetermined wavelength;

an optical combining portion for combining the optical-modulated signal outputted from said optical modulating portion and the light from said local light source;

an interference portion for separating the combined optical signal outputted from said optical combining portion into a plurality of optical signals having predetermined difference in propagation delay and then combining the optical signals;

an optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from said interference portion into an electrical signal; and

a dividing portion for separating the electrical signal outputted from said optical/electrical converting portion for each of frequency components and outputting the electrical signals.

51. An optical transmission system for optically transmitting an angle-modulated signal, comprising:

an optical modulating portion for converting said angle-modulated signal into an optical-modulated signal;

an optical branch portion for branching the optical-modulated signal outputted from said optical modulating portion

into two signals at least, a first optical-modulated signal and a second optical-modulated signal;

an interference portion for separating the first optical-modulated signal outputted from said optical branch portion into a plurality of optical signals having predetermined difference in propagation delay and then combining the optical signals;

a first optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from said interference portion into an electrical signal;

a local oscillation portion for outputting an unmodulated signal of a predetermined frequency; and

a second optical/electrical converting portion, having square-law-detection characteristics, in which its bias is modulated with the unmodulated signal from said local oscillation portion, for converting the second optical-modulated signal outputted from said optical branch portion into an electrical signal.

52. An optical transmission system for optically transmitting an angle-modulated signal, comprising:

an optical modulating portion for converting said angle-modulated signal into an optical-modulated signal;

an optical branch portion for branching the optical-

modulated signal outputted from said optical modulating portion into two signals at least, a first optical-modulated signal and a second optical-modulated signal;

an interference portion for separating the first optical-modulated signal outputted from said optical branch portion into a plurality of optical signals having predetermined difference in propagation delay and then combining the optical signals;

a first optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from the interference portion into an electrical signal;

a second optical/electrical converting portion, having square-law-detection characteristics, for converting the second optical-modulated signal outputted from said optical branch portion into an electrical signal;

a local oscillation portion for outputting an unmodulated signal of a predetermined frequency; and

a mixing portion for mixing the electrical signal outputted from said second optical/electrical converting portion and the unmodulated signal outputted from said local oscillation portion and outputting the resultant signals.

53. An optical transmission system for optically transmitting two signals at least, a first electrical signal

and a second electrical signal simultaneously, comprising:

an angle modulating portion for converting said first electrical signal into an angle-modulated signal;

a combining portion for combining said angle-modulated signal and said second electrical signal;

an optical modulating portion for converting the combined signal outputted from said combining portion into an optical-modulated signal;

an optical branch portion for branching the optical-modulated signal outputted from said optical modulating portion into two signals at least, a first optical-modulated signal and a second optical-modulated signal;

an interference portion for separating the first optical-modulated signal outputted from said optical branch portion into a plurality of optical signals having predetermined difference in propagation delay and then combining the optical signals;

a first optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from said interference portion into an electrical signal; and

a second optical/electrical converting portion, having square-law-detection characteristics, for converting the second optical-modulated signal outputted from said optical branch portion into an electrical signal.

54. The optical transmission system according to claim 53, wherein an occupied frequency band of said first electrical signal, an occupied frequency band of said second electrical signal and an occupied frequency band of said angle-modulated signal do not overlap with each other.

55. The optical transmission system according to claim 53, further comprising:

a first signal processing portion for limiting the occupied frequency band of said first electrical signal; and

a second signal processing portion for limiting the occupied frequency band of said second electrical signal.

56. The optical transmission system according to claim 55, further comprising:

a third signal processing portion for passing only a frequency component corresponding to the occupied frequency band of said first electrical signal as to the electrical signal outputted from said first optical/electrical converting portion and reproducing waveform information which was lost by the band limitation in said first signal processing portion; and

a fourth signal processing portion for passing only a frequency component corresponding to the occupied frequency band of said second electrical signal as to the electrical



signal outputted from said second optical/electrical converting portion and reproducing waveform information which was lost by the band limitation in said second signal processing portion.

57. An optical transmission system for optically transmitting a plurality of electrical signals, comprising:

a plurality of angle modulating portions for converting each of said plurality of electrical signals into an angle-modulated signals;

a combining portion for combining the angle-modulated signals outputted from said plurality of angle modulating portions;

an optical modulating portion for converting the combined signal outputted from said combining portion into an optical-modulated signal;

an optical branch portion for branching the optical-modulated signal outputted from said optical modulating portion into a plurality of optical-modulated signals; and

an plurality of optical signal processing portions, provided corresponding to the plurality of optical-modulated signals outputted from said optical branch portion respectively, for each performing predetermined optical signal processing and then individually reproducing said plurality of electrical signals, and

each of said optical signal processing portions including:

an interference portion for separating the optical-modulated signal outputted from said optical branch portion into a plurality of optical signals having difference in propagation delay decided according to frequencies of angle-modulated signals to be acquired by demodulation and then combining the optical signals; and

an optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from said interference portion into an electrical signal.

58. The optical transmission system according to claim 57, wherein occupied frequency bands of said plurality of electrical signals and occupied frequency bands of said plurality of angle-modulated signals do not overlap with each other.

59. The optical transmission system according to claim 57, further comprising a plurality of signal pre-processing portions for limiting the occupied frequency bands of said plurality of electrical signals.

60. The optical transmission system according to claim 59, wherein each of said plurality of optical signal processing portions further includes a signal post-processing portion for

passing a frequency component corresponding to an occupied frequency band of an electrical signal to be reproduced and reproducing waveform information which was lost by the band limitation in said signal pre-processing portion as to the electrical signal outputted from said optical/electrical converting portion.

61. An optical transmission system for optically transmitting a multichannel angle-modulated signal obtained by subjecting plurality-channel electrical signals to angle modulation respectively and frequency-division multiplexing, comprising:

an optical modulating portion for converting said multichannel angle-modulated signal into an optical-modulated signal;

an optical branch portion for branching the optical-modulated signal outputted from said optical modulating portion into a plurality of optical-modulated signals; and

a plurality of optical signal processing portions, provided corresponding to the plurality of optical-modulated signals outputted from said optical branch portion respectively, for each performing predetermined optical signal processing and then reproducing an electrical signal on an individual channel, and

each of said optical signal processing portions including:

an interference portion for separating the optical-modulated signal outputted from said optical branch portion into a plurality of optical signals having difference in propagation delay decided according to frequencies of electrical signals on channels to be reproduced and then combining the optical signals; and

an optical/electrical converting portion, having square-law-detection characteristics, for converting the combined optical signal outputted from said interference portion into an electrical signal.